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09/674660

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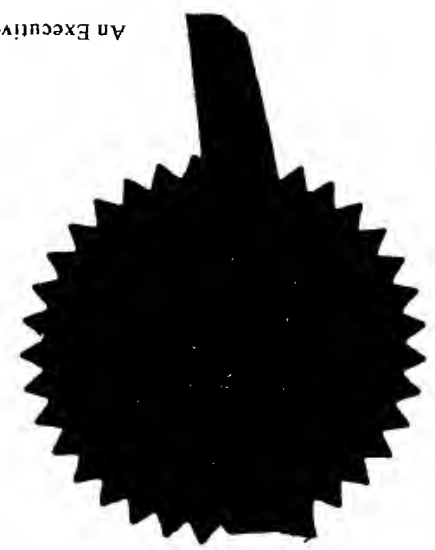


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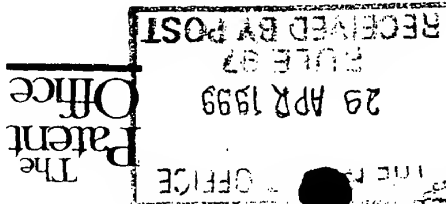
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304FR99 E443650-6 D01559  
P01/7700 0.00 - 9909856.8

**Request for grant of a patent**  
(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form.)

1. Your reference

MJ/TM/STS.33

2. Patent application number

(The Patent Office will fill in this part)

9909856.8

3. Full name, address and postcode of the or of each applicant (underline all surnames)

Surface Technology Systems Limited,  
Imperial Park,  
Newport,  
NP1 9UJ.

Patents ADP number (if you know it)

07539679001

If the applicant is a corporate body, give the country/state of its incorporation

United Kingdom

4. Title of the invention

"Chlorotrifluorine Gas Generator System

5. Name of your agent (if you have one)

Wynne-Jones, Laine & James

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

22 Rodney Road,  
Cheltenham,  
Gloucestershire,  
GL50 1JJ.

Patents ADP number (if you know it)

1792001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number

n/a

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

n/a

Date of filing (day / month / year)

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if: a) any applicant named in part 3 is not an inventor, or b) there is an inventor who is not named as an applicant, or c) any named applicant is a corporate body. See note (d))

YES

# "Chlorotrifluorine Gas Generator System"

Chlorotrifluorine ( $\text{ClF}_3$ ) is known to be a likely candidate to achieve an improved etch process capability and has recently become increasingly utilized as a "dry chamber-clean" gas to remove very effectively deposits and build-up after other plasma processes. This is more effective and used in preference to gases such as  $\text{NF}_3$  which are also highly toxic, but require plasma or other excitation means to allow etching at acceptable rates.

The prior art comprises two alternative methods of  $\text{ClF}_3$  supply, either using a conventional cylinder containing the precursor gas or by local electrolytic cell generation. Cylinder  $\text{ClF}_3$  gas delivery systems are most commonly used and have been discussed in detail by Verma et al (Semiconductor International, July 1997, p253). Issues such as compatibility of installation materials and thermal gradients require particular attention. These design considerations can have a significant impact on the overall performance of the process.

Supply of  $\text{ClF}_3$  has been available in liquid cylinder form and, very recently, developments have focused on the availability of "dry" cartridge delivery systems. This allows the delivery of  $\text{ClF}_3$  (in a nitrogen carrier gas), with the advantages that there are neither liquid filled cylinders of extremely hazardous  $\text{ClF}_3$  to be transported nor any special storage requirements on-site, as the dry cartridge is solid at ambient temperatures. A limitation of either

the liquid cylinder or dry cartridge  $\text{ClF}_3$  delivery system

that they are both subject to fluctuations in the ambient conditions, which could affect the process reproducibility.

$\text{ClF}_3$  (which is a liquid at ambient temperature) is delivered

from a conventional cylinder as a low vapour-pressure gas.

To achieve the high gas flow rates and pressures required

for processing, a single cylinder using an external-heating

jacket is commonly used. This poses additional

facilitation and safety requirements in order to prevent

gas condensation in the delivery lines and components. The

situation may be further aggravated depending upon applica-

tion. For example if the gas is used in applications where

it may be switched with another process gas, then the

changes in the flow demands of the process may cause the gas

to liquefy in the gas lines. This is because of the

variable pressure, temperature and flow parameters experi-

enced by the gas delivery system during this process.

Newer delivery systems based on electrolytic cell

generation overcome some of these limitations. Such systems

are only just becoming commercially available. However a

dedicated  $\text{ClF}_3$  delivery installation is still needed.

Limitations of this dry cartridge  $\text{ClF}_3$  delivery system

include gas flow fluctuations caused by changes in the

ambient conditions which will, in turn, affect the process

reproducibility. The cost of the process gas is similar to

that for supply of  $\text{ClF}_3$  in liquid form but the dry cartridges

require exchanging and this will require a service infra-

structure and support to be established. In addition, this

method only allows  $\text{ClF}_3$  to be generated in the presence of an  $\text{N}_2$  carrier gas.

$\text{ClF}_3$  suffers from a combination of increased cost over existing chemistries, greater health and safety risks and limited commercial availability. These factors combine to make the economics and practicalities of implementing this chemistry potentially difficult and/or the installation and transportation thereof extremely hazardous.

According to the invention there is provided a  $\text{ClF}_3$  gas generation system wherein supply sources of chlorine and fluorine are connected into a gas reaction chamber enabling generation of  $\text{ClF}_3$  gas, and the reaction chamber has a valved outlet for the supply of the  $\text{ClF}_3$  gas.

The invention further extends to such a gas generator system wherein the valved outlet from the reaction chamber is connected to a single or multiple process chamber or processing tool in which the  $\text{ClF}_3$  gas will be utilised.

This invention provides for the generation of  $\text{ClF}_3$  process gas on demand. The  $\text{ClF}_3$  is generated locally to the process tool through the direct combination of the precursor gases, fluorine and chlorine, under controlled temperature and pressure reaction conditions. The use of the individual precursor gases offers a considerable improvement over many of the economic, and handling constraints of current methods of supplying  $\text{ClF}_3$ . In particular, the recent commercial availability of an appropriately scaled local high-purity fluorine generator overcomes many of the safety issues of handling pure high-purity fluorine required for the reac-

tion.

Direct reaction of  $Cl_2$  and  $F_2$  allows the local gener-

ation of the  $ClF_3$  although the specific reaction products resulting from the reaction may include other reaction by-

products species in the form of  $Cl^*F_y$ , but the dominant

species can be maintained as  $ClF_3$ . Apart from the reaction

by-product species, the generated gas can be formed to the

same high purity levels as the precursor gases. This high

purity is easier to maintain in a smaller scale reaction

chamber compared to much larger commercial volume generation

systems. For the majority of applications envisaged, the

other  $Cl^*F_y$  species are not expected to represent any process

issues over  $ClF_3$  alone. Other benefits of this invention

include lower production cost and ownership costs as well as

reduced hazard to personnel.

The reaction chamber can be formed from high purity

materials (such as those sold under the Trade Marks Monei

(nickel/copper/iron alloy), Inconel (nickel/chromium/iron

alloy) and Hastalloy (nickel/molybdenum/chromium/manganese

/iron alloy) which would not be financially feasible with

large scale generation systems.

The gas generator for the invention operates with known

precursor gases at or near atmospheric pressure, thus

virtually eliminating the need for specialised gas delivery

systems. Ideally though the gas generation system will be

provided with a control system to control the rate of supply

of gases from the two supply sources and through the valved

outlet from the reaction chamber.

The reaction chamber may be operated at or near atmospheric pressure, going up the range from several Torr to 760 Torr. The reaction chamber temperature can be controlled at between ambient room temperature up to 600°C generally, but probably will lie within the range of 100 - 400°C. Differing temperatures may be maintained in at least 2 separate zones of the reaction chamber.

The most hazardous gas used in the installation will be  $\text{Cl}_2$ , which is already commonly used in most fabrication plants in the utilisation of semiconductor manufacturing techniques. Other than this, there are no extremely

hazardous gases in the installation, until the process demands gas generation (of fluorine gas, followed by  $\text{ClF}_3$ ). This reduces hazardous chemical storage problems and risk of

corrosion etc. Long gas lines for the local generation of fluorine on demand from a central store on the installation to the processing environment are eliminated along with the associated risks. Specialised gas delivery systems, containing hazardous chemicals, to the process equipment are

also eliminated, which reduces the level of safety precautions needed to protect the operator during use and during any maintenance operations. The generation of the process gas from the  $\text{ClF}_3$  gas generator is very competitive as compared with the cost requirement using high-pressure

cylinders for the actual gas supply. There would be a significant reduction in the installation cost due to the reduced amount of pipe work for the additional gases and the associated safety requirements such as gas monitoring

systems.

The direct combination of precursor gases can provide  $\text{ClF}_3$  for the process chamber by passing the relatively safe precursor gases through a simple heated and pressure-controlled reaction chamber that is local to the tool. The

design of the system will be such as to avoid possible adverse reactions during the combination of the precursor gases that may prejudice the overall process. The  $\text{ClF}_3$  reaction chamber design allows operation at pressures independent of the process chamber pressure. This can be

achieved by allowing the gas product to flow into the process chamber via a pressure control system. The process chamber is then independent of the higher pressure in the reaction chamber and the delivery pressure of the supplied fluorine and chlorine.

The introduction of high purity gases removes the need to "polish" the generated  $\text{ClF}_3$  to remove unwanted impurities before passing into the process chamber. The generation of fluorine locally to the tool overcomes the commercial difficulties in obtaining high purity 100% fluorine in a high pressure cylinder and in the quantities required. The choice of supply of chlorine is from high-pressure cylinders, which are commercially readily available and commonly installed within the industry. Other appropriate methods of chlorine simply may be used. Mass flow controllers may be used to precisely meter the flow of  $\text{Cl}_2$  and  $\text{F}_2$  into the reaction chamber.

The safety requirements for the precursor gases are



already commonplace for the targeted industry. This is not the case for chlorotrifluorine. The production of chlorotrifluorine within a sub-component of a process tool eliminates additional safety precautions that would need to be taken for the supply of such gas from a centralised store. The maintenance of the complete system is eased by the absence of any  $\text{ClF}_3$  when the system is not being used for processing.

The quantity of the generated gases can be regulated to that required for the specific application so that the gas consumption is optimised and excess generated gas avoided. The design of a custom-built fluorine-on-demand generator ensures that the  $\text{ClF}_3$  is only produced as required from the reaction chamber. The flow rates that can be achieved are not subject to gas delivery restrictions which might be proscribed for  $\text{ClF}_3$  delivery from a central store.

The invention may be performed in various ways and a preferred embodiment thereof will now be described, by way of example, with reference to the accompanying drawing, which is a diagrammatic illustration of a typical system of the invention.

The system shown in the drawing is for supplying chlorotrifluorine to a process chamber 1 where a dry process utilising that gas is to take place. The  $\text{ClF}_3$  is delivered from a local reaction chamber 2 where precursor gases chlorine and fluorine are combined under conventional heat and pressure controlled conditions. The chlorine source is a cylinder 3 of compressed chlorine. The fluorine source is

a conventional fluorine generator 4. Appropriate valving will include valves provided at A, B, C and D for appropriate isolation and control means. Linked control systems 5 and 6 monitor and maintain the supply to and conditions in the chambers 1 and 2.

From the process chamber gases pass to an exhaust system 7, which in turn leads to an abatement tool 8 (which is usually needed). A bypass outlet 9 leads from the reaction chamber 2 to the exhaust system, whereby gases can be switched into the process chamber 1 only when required for processing. This also allows means for ensuring stable gas composition and flow to be maintained prior to switching into the process chamber.

# CLAIMS

1. A  $\text{ClF}_3$  gas generation system wherein supply sources of chlorine and fluorine are connected into a gas reaction chamber enabling generation of  $\text{ClF}_3$  gas, and the reaction chamber has a valved outlet for the supply of the  $\text{ClF}_3$  gas. 5
2. A system according to claim 1, wherein the chlorine supply source comprises a cylinder of compressed chlorine. 10
3. A system according to claim 1 or claim 2, wherein the fluorine supply source is a fluorine generator. 15
4. A system according to any one of claims 1 to 3, wherein a control system is provided to control the rate of supply of gases from the two supply sources and through the valved outlet from the reaction chamber. 20
5. A system according to any one of claims 1 to 4, wherein the valved outlet from the reaction chamber is connected to a process chamber or processing tool in which the  $\text{ClF}_3$  gas will be utilised. 25
6. A system according to claim 5, wherein an abatement tool is connected from the output of the processing chamber or tool. 30
7. A system according to claim 6, wherein a bypass connection is provided from the reaction chamber to the abatement tool to enable the process to build up to a stable composition and/or flow prior to supply of the generated  $\text{ClF}_3$  to the process chamber or tool. 35
8. A system according to claim 6, wherein a bypass

connection is provided from the reaction chamber to the abatement tool to enable the flow of  $\text{ClF}_3$  to be switched into the process chamber as and when required to allow a continuous generation of  $\text{ClF}_3$ .

5 9. A method of generating  $\text{ClF}_3$  gas using a system as claimed in any one of claims 1 to 8, wherein the precursor gases are fed from the supply sources to the reaction chamber, a combination reaction is performed and the  $\text{ClF}_3$  reaction product is fed on to a local processing chamber or tool.

10. A gas generation system or method for generating  $\text{ClF}_3$  gas and substantially as herein described with reference to the accompanying drawings.

